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D9.6 Tailored HF-RTP and Methodology Vs1.5 for the Automotive Domain

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Executive Summary

The following document describes the process of adaptation of the HF-RTP, which is being developed in the HoliDes project (WP1), to the Automotive domain, with a special focus on the description of the AdCoS and tool chains developed by the partners. It is the follow up deliverable of D9.4, which was the first tailoring period. It is explained how the tailoring methodology provided by WP1 is applied in the Automotive Domain.

This document is the result of many collaboration activities between the AdCoS developers in WP9 and the method tools and technology (MTT) providers in WP 2 to 5. There are many MTTs in HoliDes but not all of them are relevant for every AdCoS. Those which can assist in the Control Room domain design processes are listed here.

1 Introduction

This deliverable describes how the HF-RTP methodology Vs1.5 and the HF-RTP, which are being developed in WP1, are applied and tailored in the Control Room domain. In particular, it focuses on the application of the tailoring rules provided by WP1 and defined in D1.4.

1.1 Objective of the document

Deliverable D9.6 describes the results of the HF-RTP tailoring methodology applied to the Control Room domain for the third project cycle.

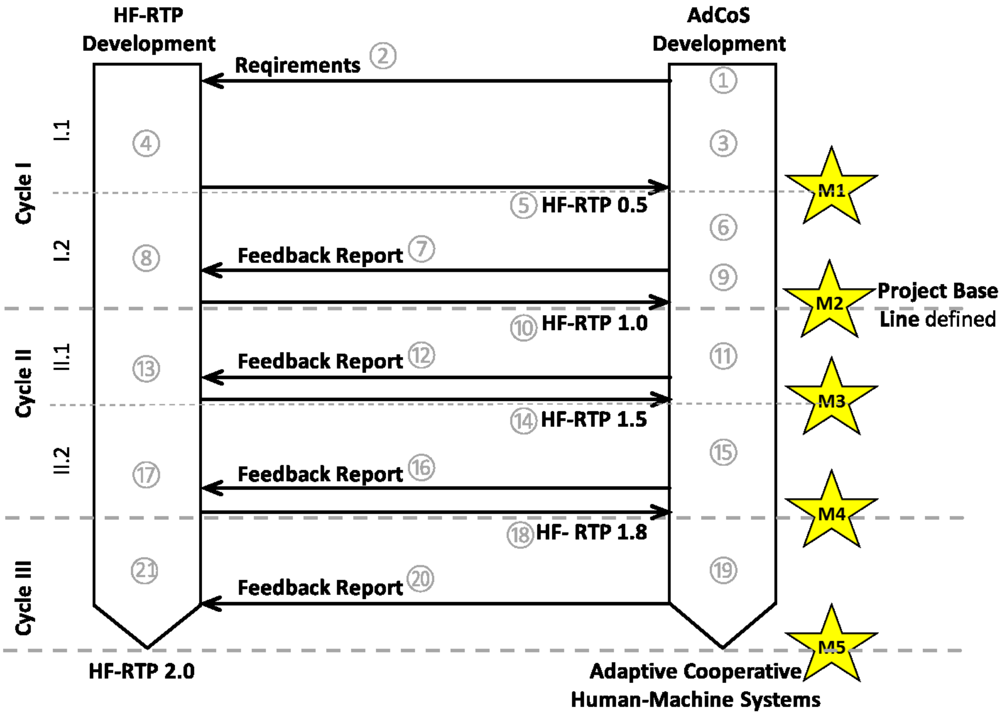

Figure 1: Overall workflow taken from the HoliDes proposal.

The HF-RTP and the tailoring methodology (version 1.5) developed in WP1 and delivered in D1.4 are applied to the AdCoS of the Control Room domain.

The previous version for tailoring of the HF-RTP in WP9 has already been provided in D9.4, which was based on the HF-RTP version 0.5 (M1).

1.2 Structure of the document

This document goes ahead to the content delivered in the previous tailoring process of the HF-RTP in D9.4. As it has been detailed in the document D1.5, the HF-RTP methodology has been deployed, and the main purpose of this document updates the status of that tailoring process using a common structure agreed and implied by the tailoring rules.

The section 2 details and reviews the HF-RTP tailoring methodology, focusing in the Automotive domain with the particularities it has. The HF-RTP Common meta model and HF ontology are described and related to the use cases being solved within WP9. Then, applicable tools and method libraries are being discussed and the tailoring process is being reviewed. Section 3 captures the current status of development of the different AdCoS of the HoliDes Automotive domain. Section 4 details the inclusion of the HF-RTP methods and tools into the AdCoS. Finally, *conclusions and summary* are extracted, and the way forward and upcoming activities for the future are dealt with.

2 Meta Modelling

The purpose of this section is the clarification of how meta models and ontologies developed under the umbrella of WP1 have been used in the development of the different AdCoS of the Automotive domain. Each AdCoS has its particular subsection of this chapter.

2.1 AdCoS Adapted Assistance

The current version of the Adapted Assistance AdCoS was not based on the Human Factors Common Meta-Model delivered in D1.5, since it was not available during the planning phase (true also for the IAS demonstrator).
However, the platform used in CRF vehicle is based on RT-MAPS framework, provided by INT partner and it includes many tools and modules developed by partners from WP2-WP5.

2.2 HMI of the Lane Change Assistant developed for CRF

No metamodels and ontologies developed under the umbrella of WP1 have been used in the development of the HMI of the Lane Change Assistant developed by CRF in the Automotive domain, because the Human Factors Common Meta-Model (HF-CMM) as described in Deliverable D1.5 was not yet available at the time the first version of the HMI was built.

2.3 AdCoS Adapted Automation

The current version of the Adapted Automation AdCoS was not based on the Human Factors Common Meta-Model delivered in D1.5, since it was not available during the planning phase.

2.4 AdCoS Virtual HCD Platform

In its current status, the V-HCD platform is an operational simulation platform already integrating several MTTs developed in HoliDes, interconnected with RT-MAPS software (detailed description available in D4.4): COSMODRIVE (as a driver simulation model), MOVIDA (as a monitoring device in charge to adapt the AdCoS and manage Human-Machine Cooperation according to the situational Risk), and virtual ADAS models simulated with Pro-SIVIC (detailed description in D9.4). However, the Meta-Modelling approach was used to describe the V-HCD platform at a more conceptual level, through the characteristics of the different MTTs currently integrated in this simulation platform, in order to support potential future exchanges with other MTTs currently under development in the project.

More precisely, data from our different MTTs are sent to RT-Maps, in order to be shared with the other tools. Data and concept which can't be exchanged with RT-Maps are usually specified with UML or other modelling language (e.g. XML), which can be shared using many different communication protocols defined in the Meta model. Meta-Modelling is really useful to determine the common data and the different communication protocols.

2.5 AdCoS Adaptive HMI

No meta-modelling was applied for the first version of the adaptive HMI. The reason is that the communication between the MTTs applied was based on interoperability in the first place without any further models. Secondly, the Human Factors Common Meta-Model (HF-CMM) as described in Deliverable D1.5 was not yet available at the time the first version of the adaptive HMI was built.

3 Tailoring Steps

3.1 Revisions to the tailoring steps

Tailoring rules are supposed to be the guidelines to show how the RTP is tailored for a particular use.

3.1.1 AdCoS Adapted Assistance

The tailoring steps have been not changed from D9.4, where the steps had already been rephrased and therefore also fit for the current Version 1.5 (same situation of IAS demonstrator).

3.1.2 HMI of the Lane Change Assistant developed for CRF

The application of the tailoring rules (v1.0) for the HMI developed by REL has been provided in detail in D9.4, where the steps have already been rephrased according to the overall process described in D1.5.

Here is a summary of this adaptation of the steps for REL.

Step 1 was the description of the development process of the HMI for the CRF AdCoS and the identification of issues where MTTs could help to improve the development process and the system quality (as described in D9.4).

Tailoring step 2 was the selection of MTTs which can be integrated into the development process to solve some issues. In this cycle, the selected MTTs for this AdCoS are shown in Figure 2 **Fehler! Verweisquelle konnte nicht gefunden werden.** (in place of the yellow markers corresponding to the needs of REL).

Step 3 of the tailoring methodology was about the integration of the MTTs into the actual tool chain that is part of the development process of the AdCoS.

In particular, the mapping step described the interfaces that defined which and how information is exchanged between MTTs and existing tools. Interfaces with the HF-RTP are also defined when needed (e.g. for sharing data that could be reused by other AdCoS's, such as datasets to create models).

Finally, step 4 was the implementation of the mappings defined in step 3 (i.e. implementation of parsers to allow the tools to correctly interpret the information receive according to a predefined communication protocol).

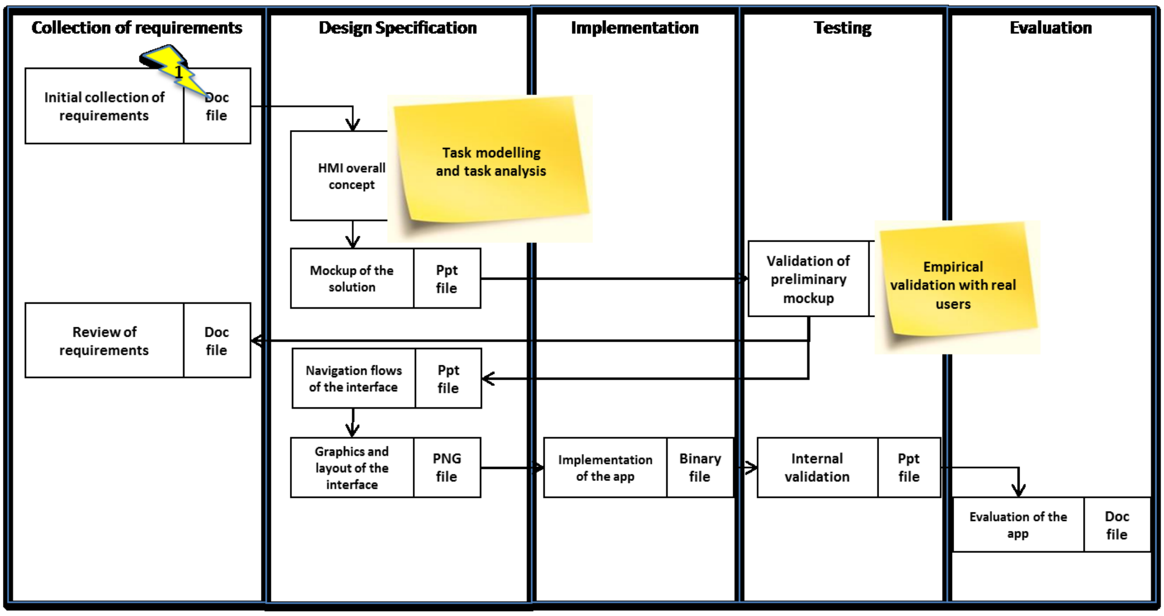

Figure 2 Selection of MTTs to improve the development process of the HMI of the Lane Change Assistant developed by CRF.

3.1.3 AdCoS Adapted Automation

The current version of the tailoring steps (V1.5) is provided in D1.5, where the tailoring steps have been rephrased from V1.0 to fit the needs of the AdCoS developers. The application of the tailoring rules (V1.0) for the IAS AdCoS has been provided in D9.4 where the steps had already been rephrased and therefore also fit for the current Version 1.5.

3.1.4 AdCoS Virtual HCD Platform

Tailoring steps from D9.4 did not change for our Virtual AdCos in the V-HCD Platform (Development process and issues, selection of the MTTs and integration), the last steps of implementation is currently undergoing.

3.1.5 AdCoS Adaptive HMI

The three tailoring steps used for the description of the AdCoS development process in Deliverable D9.4 did not change (Tailoring Step 1 – Development process and issues; Tailoring Step 2 – Selection of MTTs; Tailoring Step 3 – Integration and interfaces).

3.2 Feedback on the tailoring steps so far

3.2.1 AdCoS Adapted Assistance

At the moment, the defined tailoring steps fit with the development and implementation needs (and constraints) of the Adapted Assistance AdCoS in CRF demonstrator.
More details will be available when the full system is evaluated, that is beginning next year (2016).

For the moment, tailoring steps are especially used for the design and development of some components of the AdCoS, in particular the HMI.
More details about are provided in Section 3.2.2.

3.2.2 HMI of the Lane Change Assistant developed by CRF

By following the methodology defined in D1.5 (and partially adapting it to the actual needs of the AdCos owners), the first 3 steps of the tailoring of the HF-RTP for the HMI developed by REL have been performed.

In particular, the development process of REL has been formalized and the issues have been identified (step1).
The MTTs that have the potential to address these issues have been identified and have been selected to be tested in order to check if they can be included in the development process of REL.
Finally, the outcome (and the corresponding format) for each existing tool has been identified in order to understand how to interface them with the MTTs and the HF-RTP.
However, no mapping has been completed to describe the interfaces that defined which and how information is exchanged between the selected MTTs and existing tools in the development process of REL, mainly because methodologies and techniques were employed (i.e. task analysis and focus group) that are planned to be integrated into the HF-RPT with a different process than the tools.
According to the Integration Plan (defined as annex of D2.5 and D5.4), as regards the design and results of the focus group, we plan to complete

this activity by using the HF Filer tool to collect the information of the empirical test.

Since logical interfaces have not been defined, no implementation of parsers have been performed yet.

3.2.3 AdCoS Adapted Automation

The current version of the tailoring steps (V1.5) is provided in D1.5, where the tailoring steps have been rephrased from V1.0 to fit the needs of the AdCoS developers. The application of the tailoring rules (V1.0) for the IAS AdCoS has been provided in D9.4 where the steps had already been rephrased and therefore also fit for the current Version 1.5.

3.2.4 AdCoS Virtual HCD Platform

Tailoring steps provides us information about AdCos and their synergistic, allowing a enhancement of the development process.
Steps 1 and 2 highlighted some issues, like development of driver model-based simulation, or selection of the eye-tracking system in order to generate eye-tracker output with the simulation. But, as described in D9.4 and D4.4, these steps were required for the next ones.
Step 3 and its progress take a part in our step 4, but we can confirm that this step is a major part of our work, and we currently stick to our description defined in D9.4 (particularly fig 15 of D9.4)
Step 4 is currently under progress, but seems accurate to our developments of the model, AdCos and interfaces between all MTTs.

3.2.5 AdCoS Adaptive HMI

The tailoring steps themselves proved useful.

4 Platform Builder

4.1.1 AdCoS Adapted Assistance

For the CRF AdCoS, the effectiveness of the Platform Builder has beed evaluated considering the HMI aspects, for the moment. In particular, the suggested MTTs have been compared with the MTTs actually used in the development process. More details on that can be found in the next section.

4.1.2 HMI of the Lane Change Assistant developed for CRF

We evaluated the effectiveness of the Platform Builder by comparing the MTTs it suggested with the MTTs actually used in the development process of REL (for design and evaluation, where the MTTs are used), where usability, distraction and safety are relevant HF issues.

Table 1 gives an overview of the inputs we provided for the Platform Builder.

	Domain	HF-Issue	Related Activity
Input	Automotive	Usability Distraction Safety	Design Evaluation

Table 1: Platform Builder Input for REL

As shown in Table 1, the MTTs employed in this cycle are:

- Task modelling and task analysis
- Empirical validation methods involving real users

Several combinations have been considered to test the Platform Builder. The output gives a good overview about MTTs which can be used to address needs similar to the ones REL experience in its development process.

Since there is still room for improvement, the following issues and suggestion could be considered:

- **Multiple selection:** multiple HF issues should be selected simultaneously.

- **MTTs:** It suggested several MTTs, and it actually provides good hints about MTTs that REL could actually employ to improve its development process. However, the MTTs actually used by REL have not been listed.
- **Keywords:** it would be great if it could select MTTs according to some keywords inserted by the user

4.1.3 AdCoS Adapted Automation

The Platform Builder has been evaluated for comparison between the currently selected MTTs for the AdCoS development process and the suggested ones. Since the Adapted Automation AdCoS is completely developed within the project, a HF-RTP instance from the Platform Builder is generated for multiple development steps (requirements engineering, design, implementation, evaluation).
Moreover, since the AdCoS adapts its automation to the driver's wishes, usability is the main HF issue, but also safety and workload are issues and will be selected as an input for the platform builder. The tables below give an overview of the inputs for the Platform Builder, as well as the suggested MTTs and a rationale for the MTT to be used in the development process or not.

	Domain	HF-Issue	Related Activity
Input	Automotive	Usability Workload Safety	Requirements Engineering Design System Implementation Evaluation

Table 2: Platform Builder Input

MTT	used	Rationale
HF-Guideline	yes	The Human Factors Guideline could be used to define the system and all relevant aspects comprehensively and identifying potential issues in the system design at an early stage in the project. The number of iterations for designing the system could be reduced.
Theatre Technique for acceptance tests and systems variants	yes	The Theatre Technique is used to explore design alternatives for the fluent task handover between human

exploration during AdCoS design		driver and automation. Due to its Wizard-of-Oz approach, this technique will allow the designers and human factors expert to explore possible functions without the necessity of implementation.
Methods and techniques for the driver adaptive parameterization of a highly automated driving system	yes	This activity encompasses the empirical studies necessary to determine driver styles and design appropriate automation driving styles. Data from the experiments are used to implement the CONFORM-module.
Djnn	no	A graphical user interface is not intented to be part of the AdCoS
CONFORM	yes	This driver model is implemented in the AdCoS to characterize the individual driving style of the human driver in real time. This information is used in the real time system to adapt the driving style of the automation according to the individual driver. The relation between manual driving style and preferred automation characteristics is determined through user studies.
HEE	no	The purpose of the AdCoS is not to improve the efficiency of the human while driving, but to adapt to human wishes.

Table 3: Output of the Platform Builder for the IAS AdCoS

The Platform builder has been used for various input combinations to fit the requirements for the AdCoS development. The output gives a good overview about MTTs which can be used throughout the development process.

Since the platform builder is not finalized yet, some intended features might be missing, and some suggestions for improvements are:

- **Multiple selection:** Unfortunately only one HF-Issue and one task can be selected. Since some AdCoS will improve multiple issues (e.g. workload and safety) multiple selections should be possible.
- **Output:** The output is currently just a collection of MTTs, but no suggestion for the workflow is given. For example, it could be suggested to start with MTT1 and use the output of it as an input for MTT2
- **MTTs:** The first tests of the platform builder were surprising, since a lot of MTTs were proposed, which are not listed in the current HF-RTP (D1.5) as separate MTTs, but belong to the HF Method Library. Thus a hint on the HF Method Library should be given for those MTTs. On the other hand, tools which we expected have not been suggested.
  The issue of having a lot of MTTs in the Platform builder, which are not listed as separate tools, but belong to a library may result from the fact, that each partner can add MTTs to the Platform Builder.

4.1.4 AdCoS Virtual HCD Platform

Virtual HCD platform allows a connection through RT-Maps to any other system, with dedicated specification in order to manage information flow between Virtual HCD Platform and other platform.
HF Issues, like drivers' distraction or effect of the AdCoS on drivers' behaviour, are the inputs of the platform. Virtual HCD platform and its different MTTs, using RT-Maps as communication channel, provide the input of the Platform Builder.

	Domain	HF-Issue	Related Activity
Input	Automotive	Distraction Safety	Virtual Design Evaluation

Table 2: Platform Builder Input for IFS

Resulting from that, the platform builder did not provide us new relevant MTTs for the HF issues we're exploring, but confirm our selected MTTs (COSMODRIVE and MOVIDA, cf. description in D4.4 and D9.4).

Therefore, the development process will be focused on COSMODRIVE and MOVIDA in order to simulate drivers' behaviour, cognitive activities and co-piloting system in Pro-SiVIC's simulated environment, using RT-Maps as the communication channel to keep the data synchronised and allow recordings.

4.1.5 AdCoS Adaptive HMI

The platform builder (for a first description, see also Deliverable D1.5) was not used for the first version of the adaptive HMI. It is planned to use it for the final version. However, because the MTTs that will be used have already been decided upon, the full advantage of using the platform builder might not fully show.

5 AdCoS Development

5.1.1 AdCoS Adapted Assistance

5.1.1.1 Overview of the AdCoS

As described in details in the previous deliverables (D9.3-D9.5), the CRF AdCoS is named *Adapted Assistance* and constitutes in a Lane-Change Assistant (LCA) system, which is able to adapt to the internal and external scenarios. This means that the "optimal" manoeuvre is suggested from machine-agent to human-agent, by means of specific warnings, advice and information, according to the visual state and intentions of driver, as well as to the external environment.

The LCA system comprehends two main use-cases (functionalities):

- Lane-Change Assistant (LCA) and Overtaking Assistant (OA)
- Forward Collision Warning (FCW).

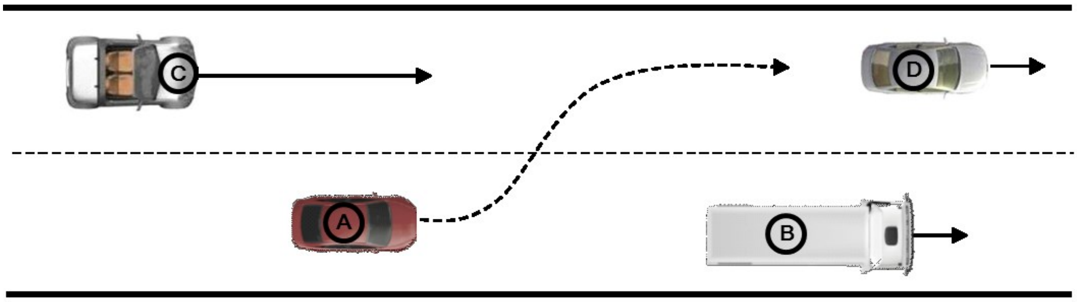

Figure 3: representation of the LCA AdCoS with the two use-cases.

The information flow, with all the inputs and outputs from the different modules, is illustrated in the following figure:

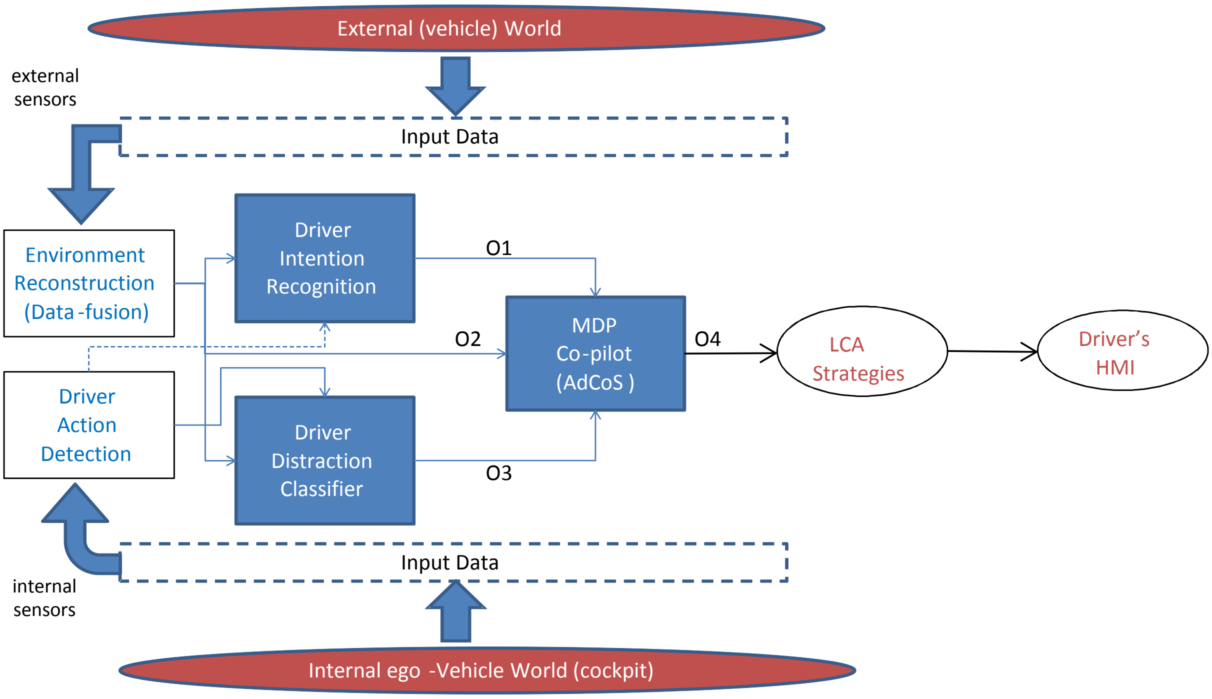

Figure 4: representation of the information flow from / to the different block in the LCA architecture.

Being an Adapted Assistance system, the "trigger" for the adaptation is the crucial point and it is represented by the state and the intention of the driver (if he/she is distracted or not, what is her/his intention).

In particular, the novelty is the advanced cooperation between human-agent and machine-agent, where the system can adapt to the driver capabilities, needs and intentions, as well as to the other road users and the environmental conditions, as illustrated in Figure 3.

It is characterized by a decentralized decision making between the artificial and the human intelligence, represented by the co-pilot; the related architecture is represented in the following figure:

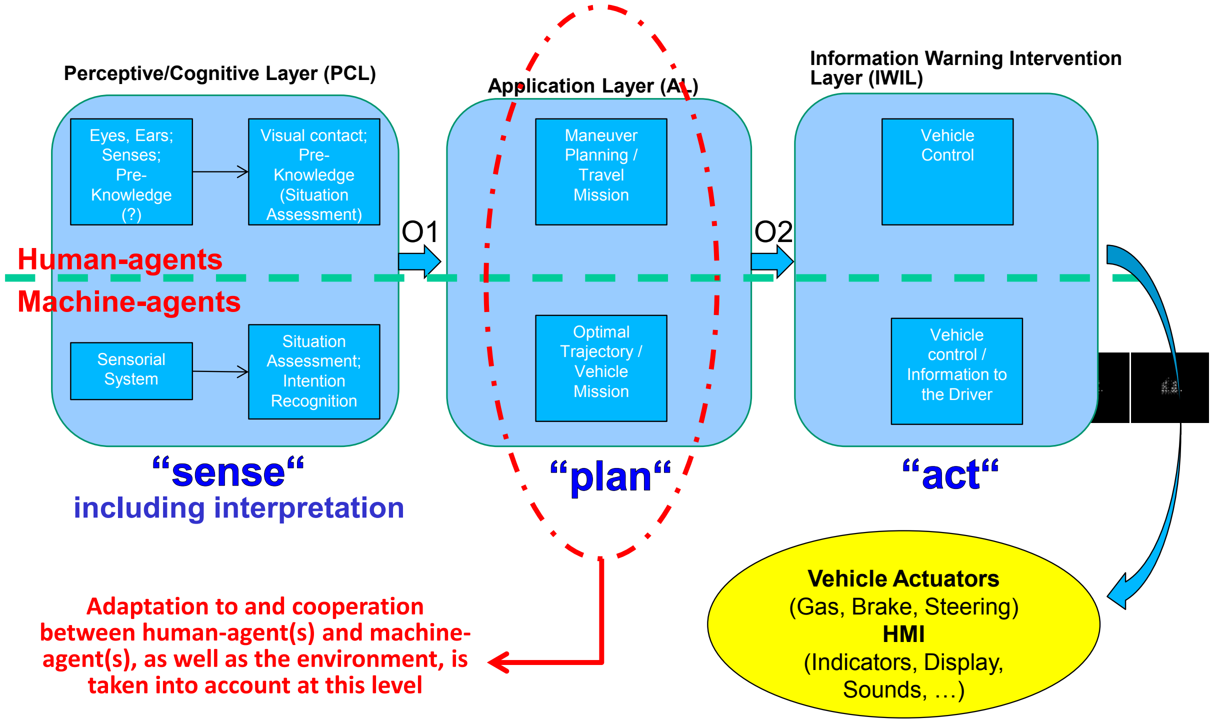

Figure 5: AdCoS architecture for the CRF test-vehicle in cycle 2.

This architecture shows how human-agent and machine-agent follow the same process. In the **perception and cognitive layer**, the external environment is perceived and interpreted, together with the cognitive state of the driver and his/her intentions/needs. The adaptation and cooperation aspects are taken into consideration in the **application layer**, where the co-pilot is implemented. It is a sort of Driver Model that analyses the behaviour of the human-agent and tries to "emulate" him/her, providing this information to the machine-agent. The machine agent can then use this information to adapt the driving style to the individual human driver. Finally, the goal of the **Information Warning and Intervention Layer** is to keep the driver informed about the detected traffic situation and the optimal manoeuvre the system will plan and suggest. This includes an appropriate HMI to communicate this information to the driver.

The roles of the partners which are involved in this AdCoS are given in the table below.

Partner	Role
IAS	• Provider of the four Laser-scanner sensors and of the features fusion system, for the complete

	reconstruction of the external environment.
DLR	• Implementation and integration of the SURT tool (to cause distraction) into the RT-MAPS framework.
INT	• Provision of the RT-MAPS SW framework and support for its maintenance and integration with the different sensors on-board.
UTO	• Development of the driver visual distraction classifier, based on the vehicle dynamic data. • Development of the co-pilot, which suggests the optimal maneuver to the human drivers, taking into account their status and intention, as well as the external conditions. • Implementation of these algorithms in RT-MAPS blocks.
OFF	• Development of the Driver's Intention Recognition module, based on Dynamic Bayesian Networks approach. • Implementation of this module into RT-MAPS framework.
REL	• Design, development and implementation of the appropriate HMI for the communication between human-agent and machine-agent.

Table 3: Role of partners for the CRF AdCoS

More details about the used MTTs are also described in Table 1 and in the text of the previous paragraphs.

5.1.1.2 Status of the AdCoS development

A Fiat 500L has been equipped with the following sensors configuration:

- A laser-scanner fusion system (four sensors) allowing a 360 degree field of view which is necessary for the complete detection of the surrounding environment.
- An external camera for the detection of the lanes (presence and types), as well as to provide the positioning of the ego-vehicle inside the lane.
- An internal camera for the detection of the driver's head position (where he/she is looking at)

The situation is sketched in the following figure, where the different sensors are shown:

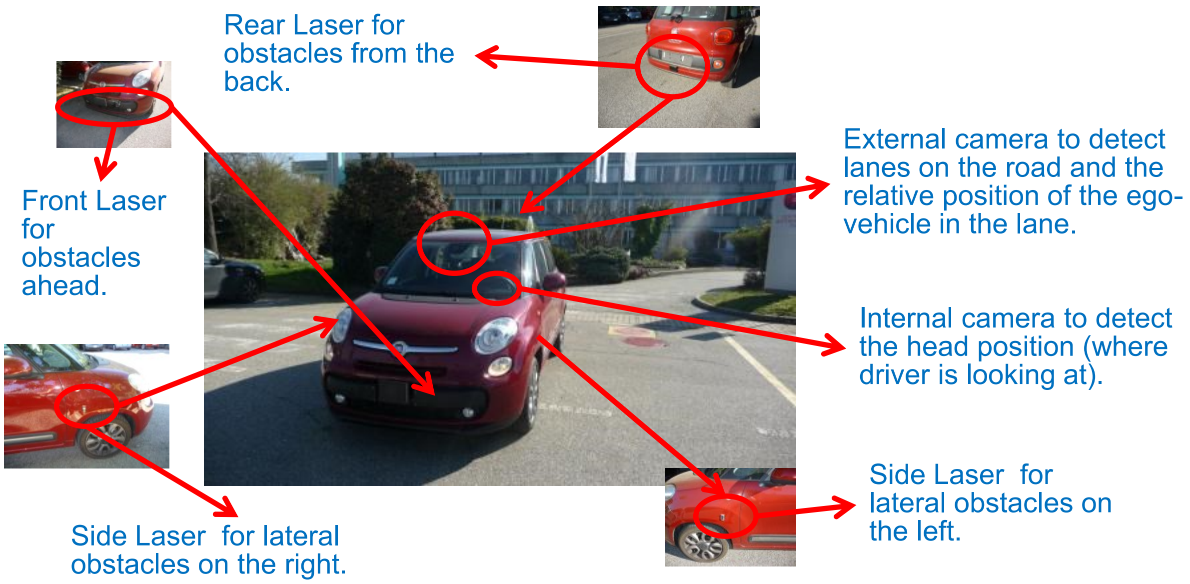

Figure 6: CRF demonstrator vehicle and related sensors type and position.

Finally, a dedicated interface to the vehicle CAN-Bus has been installed which allows sending information to the vehicle and to its HMI.

At the moment, the automotive functions are developed, in particular the trajectory planning (co-pilot algorithms) as well as the distraction classification and the intention prediction of the driver are currently on-going.
The next steps will be the focus on the integration of the adaptive strategies and on the HMI development.

5.1.1.3 Status of the Driver Intention Recognition (DIR) module development

The Driver Intention Recognition (DIR) module, developed by OFF, is a system component within the overall AdCoS application for Adapted Assistance intended to provide the MDP Co-Pilot with online-assessments of the intentions and behaviors of the human driver (c.f., Figure 4). It consists of two primary components, a domain-*dependent* part (tailored to the actual system architecture and specification of the AdCoS for adapted assistance) that primarily deals with pre-processing of the available sensor input, and a domain-*independent* part consisting of an *inference engine* that enables the DIR module to answer probabilistic queries in respect to a probabilistic model of the human operator defined in an XML-based specification. A detailed overview of the development status of the DIR module has already been provided in D9.5.

Since then, we extended the implemented inference engine to support all (conditional) probability distributions resp. density functions that are representable as canonical tables, which includes discrete probability distributions, (multivariate) Gaussian distributions, (multivariate) conditional linear Gaussians, and (conditional, multivariate) Gaussian mixture distributions. This allows us, to perform inferences in a large class of hybrid and dynamic probabilistic models, involving both continuous and discrete random variables. To enhance the computational efficiency of performing inferences, we replaced the former inference algorithms based on variable elimination with algorithms based on junction trees, which allow the simultaneous computation of multiple probability queries, making the DIR module better suited for real-time applications.

Based on datasets provided by CRF, intended for the development of algorithms and modules for distraction classification, we implemented the necessary interfaces and RT-Maps modules for data preparation. As these datasets where not applicable for the development of the actual probabilistic driver models needed for intention recognition, we relied on experimental data obtained in simulator experiments conducted prior to HoliDes that focused on comparable highway scenarios for the preparation and implementation of a general workflow for the machine-learning of the parameters and graph-structures of the probabilistic driver models (see D9.5). With dedicated datasets for intention recognition now available, we will now use this workflow to learn the final probabilistic models for the DIR module, to be integrated in the AdCoS Adapted Assistance.

5.1.2 HMI of the Lane Change Assistant developed for CRF

5.1.2.1 Overview of the AdCoS

The activity performed by REL is aimed at designing and developing an innovative HMI concept for the LC Assistant (LCA) that has been developed by CRF.

5.1.2.2 Status of the AdCoS development

So far, for the development of the HMI for the LCA of CRF REL has carried out the following activities:

- Modelling of the tasks the driver must perform to complete the lane change and the overtaking manoeuvre
- Analysis of the tasks in order to identify the cognitive and visual load of each of them

• By considering the cognitive and visual loads, the HMI concept has been defined
• A preliminary draft of the graphical interfaces has been completed, in order to associate different messages according to the state of the driver (cognitive and visual loads) and its distraction.

The activity conducted by REL was meant to identify the cognitive and visual load of each task to provide appropriate information to the driver.

Since we aimed to design an adaptive HMI that allows the driver processing information in continuously changing conditions, we planned to distribute this information where the driver is most likely to find them.

This information was provided by the task analysis that highlights where the driver is expected to look at during the LC manoeuvre.
Therefore, by using the results of the task analysis (detailed in D9.3), we designed an innovative HMI concept where the information to support the driver during the lane change is distributed:

- In the main dashboard in front of him/her
- In the internal rear mirror.
- In the external rear mirrors.

This HMI concept was meant to be an extension of the blind spot HMI, where the system warns the driver in the right rear mirrors, as shown in

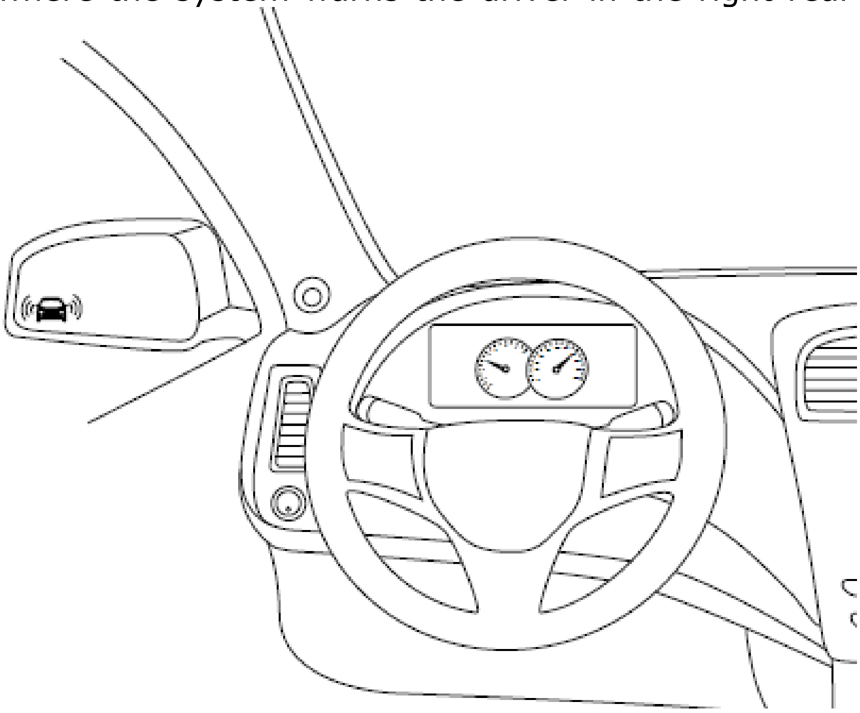

Figure 7

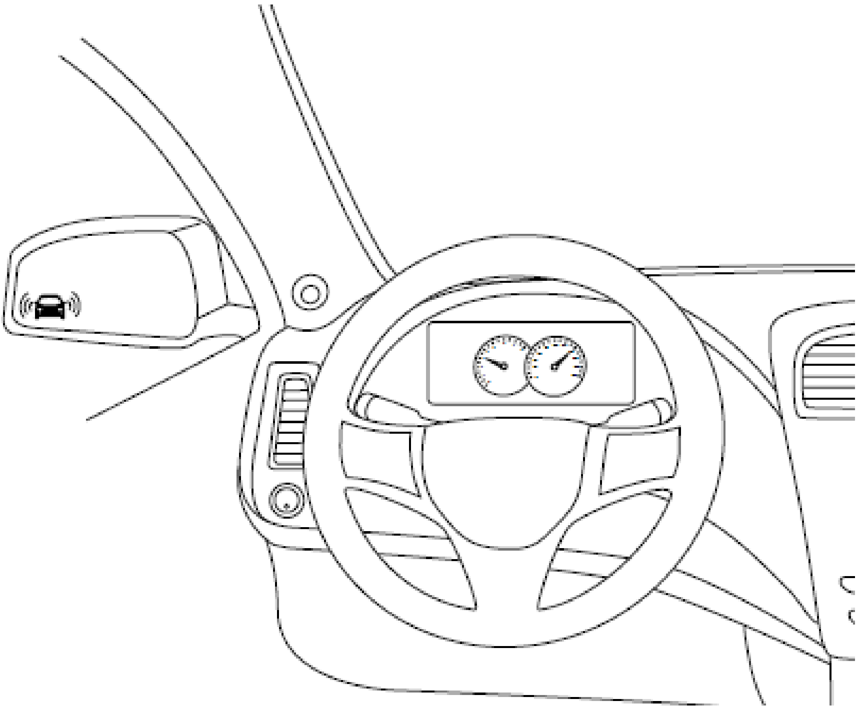

Figure 7: Blind spot HMI

Figure 8 shows the HMI concept for the LCA, where the rear mirrors have been substituted by tablets to provide the driver with a prompt warning in case of safety-critical event (e.g. a car approach when the driver is about to perform a lane change) where the driver is likely to see it.

Figure 8: Overall HMI concept to provide the information where the driver is likely to look at.

The graphical information that will be shown on the tablets has been identified in the HMI concept described in D9.3. Figure 9 shows an example of a potential warning included in the graphical HMI concept.

Figure 9: Example of a warning shown in a tablet

The tablet selected for displaying this information depend on the sub-task performed by the driver, as described in the task modelling (changing lane, car following, re-entering the original lane).
In addition, when the driver is (detected as) distracted, additional channels should be exploited in order to warn him/her in case a safety-critical event is likely to occur.

Therefore, in collaboration with WP3, REL is improving the preliminary HMI concept by including innovative communication strategies by also considering additional multi-modal (visual, acoustic, haptic and tactile) interfaces (that will be embedded in the vehicle to complement the information provided by the app).

5.1.3 AdCoS Adapted Automation

5.1.3.1 Overview of the AdCoS

Today the development of highly automated driving is the research focus of many OEMs and research institutes. A major need regarding automated vehicles is an increased usability and operability for the human driver. This encompasses cooperation and adaption of the machine agent to the human driver and other road users, with a human-centred design process as the foundation of the system development. The main challenges are the development of a fluent, yet transparent task allocation and transition between human driver and the machine agent and at the same time integrating the host vehicle into the flow of other road users, where a number of agents are acting in a shared space with shared resources. This aims at increasing the confidence of the human driver in a highly automated system, as described by vehicle automation level 3, which is defined by the NHTSA.

The novelty of the automated driving approach presented here is the advanced cooperation with a human driver and adaptation to his or her capabilities, needs and preferences, to other road users and the environmental conditions, as illustrated in Figure 1. It is characterized by a decentralized decision making between the artificial and the human intelligence.

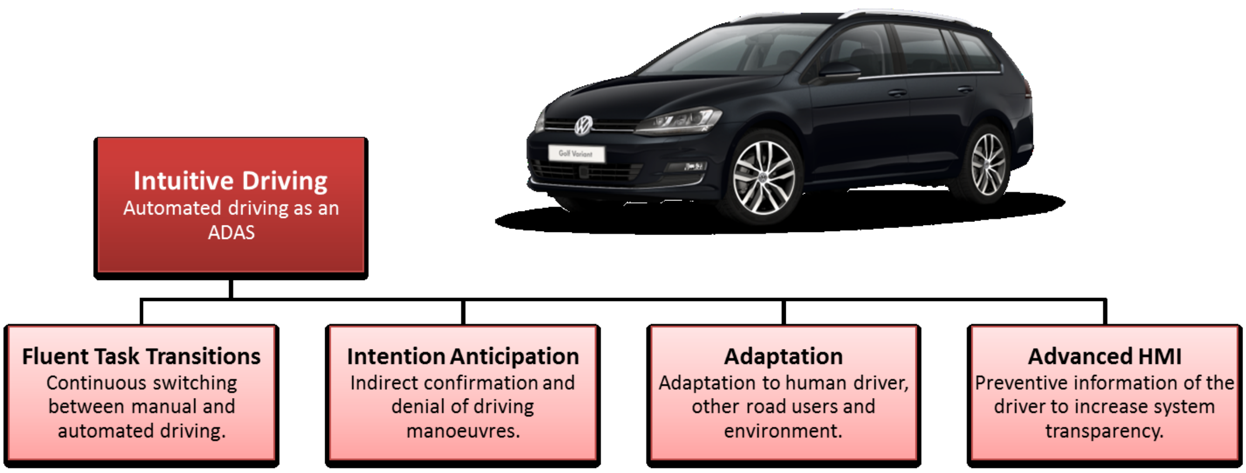

Figure 10: Key features of the Ibeo AdCoS

The highly automated driving (HAD) system is characterised by four main features, as shown in Figure 10:

1. **Fluent Task Transition.**
   The switching between manual and automated driving shall be fluent. This means that the driver can give control to the automated system at any time, while the automated driving function is available. Also the driver can interact with the automated system by operating the standard control inputs (gas, brake, steering wheel, indicators). In case the system detects that it is unable to handle an upcoming traffic situation it will warn the driver early to take over control.
2. **Intention Anticipation.**
   In case the human driver operates the pedals, the steering wheel or the indicators during automated driving, the system will automatically anticipate the driver's intention, e.g. if the vehicle is following a truck in the outer lane of a highway and the driver sets the indicator to the left, the automated system could anticipate that the driver wants to overtake and go faster.
3. **Adaptation**
   The automated vehicle will be able to determine a range of safe driving manoeuvres at any time. Within this range the system offers room to adapt the driving style according to the driver's characteristics, intentions and level of distraction.
4. **Advanced HMI**
   To keep the driver informed about the detected traffic situation and planned manoeuvres the system will include an HMI to communicate these information to the driver. The HMI is an important part of the overall system to create transparency for the human driver.

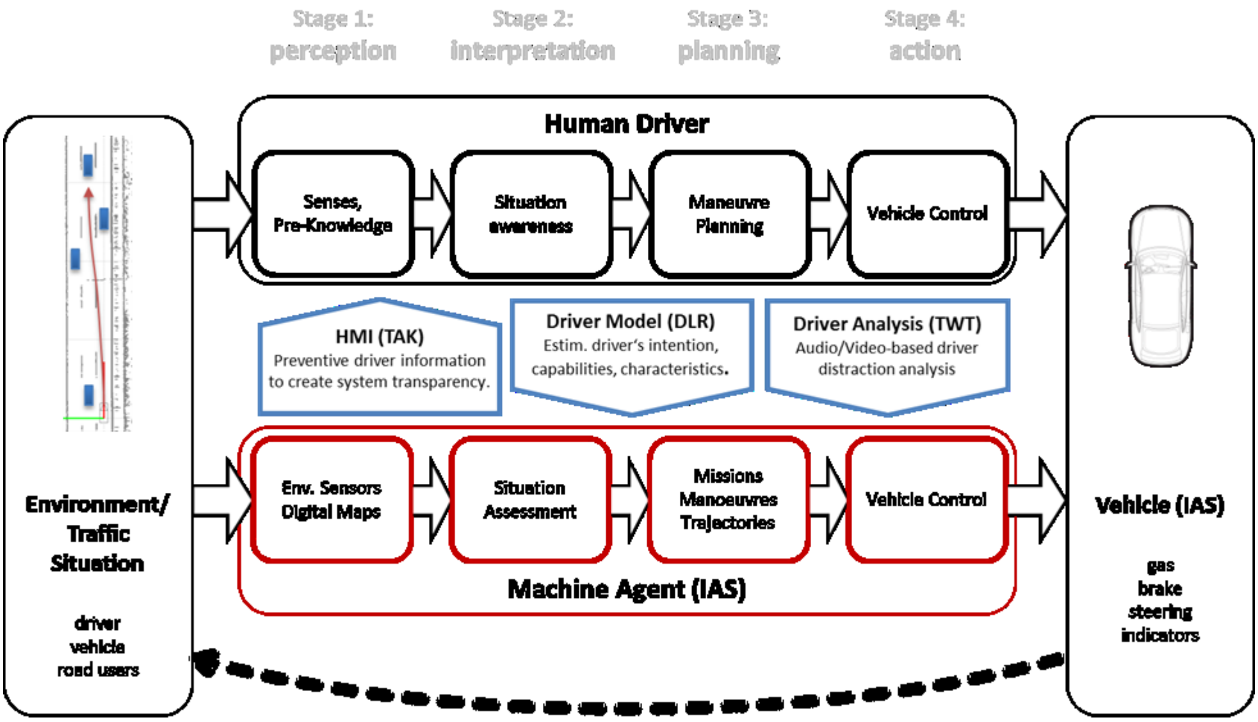

Figure 11: High Level Architecture of the Ibeo AdCoS

The process of driving can be broken down into four layers that are similar for the human driver as well as the automated system, as illustrated in Figure 11. The four layers are

1. perception,
2. interpretation,
3. planning and
4. action.

Also, Figure 11 visualises the interaction between the human driver and the machine agent. There are two modules connecting the communication flow between the human driver and the machine agent, and which close the loop of interaction:

1. **HMI**
   The HMI in this AdCoS is a display to provide information from the machine agent to the human driver. Standard control inputs, such as the pedals, the steering wheel and the indicators allow the driver to interact with the automated system.
2. **Driver Model**
   The Driver Model analyses the behaviour of the human driver and provides information about the driver to the machine agent. The

machine agent can then use this information to adapt the driving style to the individual human driver.

These two modules close the interaction loop between the human driver and the machine agent.

The roles of the partners which are involved in this AdCoS are given in the table below.

Partner	Role
IAS	• Development of the Machine Agent for Highly Automated Driving. • Coordination of the AdCoS development. • Providing interfaces for adaptation to the human driver.
DLR	• Implementing the driver model to characterize the human driver during phases of manual driving. The estimated characteristics are then used to adapt the driving style of the Machine Agent accordingly.
TWT	• Implementing an audio-based distraction estimation for the human driver to adapt the driving of the Machine Agent such that the risks during a required driver take-over is minimized during phases of high distraction.

Table 4: Role of partners for the IAS AdCoS

5.1.3.2 Status of the AdCoS development

A Volkswagen Golf VII has been equipped with a laser scanner fusion system allowing a 360 degree field of view which is necessary for the automated driving. An interface to the vehicle CAN-Bus has been installed which allows sending control commands to the vehicle.
In parallel the automotive functions are developed. The creation of digital maps, and the trajectory planning are nearly finished, and the focus will now be on the situation assessment as well as on the vehicle control.

5.1.4 AdCoS Virtual HCD Platform

5.1.4.1 Overview of the AdCoS

Deliverable D9.3 provides a good description of our AdCoS. Main functionalities are: Lane-Change Assistant (LCA), Overtaking Assistant

(OA), Forward Collision Warning (FCW), Lateral Collision Warning (LCW), and fully automated (FA) car driving, which are centrally managed by MOVIDA monitoring module.
Every component of this MOVIDA-AdCos are developed in RTMaps, with the sensor of Pro-SiVIC Software, in order to monitor the drivers and warn them if a critical manoeuvre is engaged, taking into account the specific driver state (visually distraction) and situational risk.

5.1.4.2 Status of the AdCoS development

We had performed the first trip of the virtual car with AdCos, performing an automated lane change taking into account the car oncoming on the left.

5.1.5 AdCoS Adaptive HMI

5.1.5.1 Overview of the AdCoS

The overview of the AdCoS given here is an update based on the status described in Deliverable D9.3. It is the first, not the final version of the AdCoS.
In this first version, driver distraction is not detected in real-time but is assumed as given as soon as the visual distraction task (SURT) starts. The HMI changes its characteristics based on this (assumed) state of driver distraction: When the driver is distracted and a critical situation arises, the SURT task is stopped and the critical objects are shown in the instrument cluster.
The final version of the AdCoS will be built along the draft of the system architecture as shown in Figure 49 of Deliverable D9.3. This system will contain the real-time detection of driver distraction, both visual and auditory/cognitive distraction. However, because of some minor changes of the system the requirements are currently undergoing an updating process.

5.1.5.2 Status of the AdCoS development

Because of the complexity of the system and because some MTTs are developed parallel to the AdCoS development, it was decided to divide the AdCoS development into two stages and build a first and a final version. The first version as described above has been developed, been integrated and been evaluated. The results of the evaluation will be part of Deliverable D9.9.

6 RTP Instance

All the MTTs described in deliverable D9.4 are planned to be used in the ongoing AdCoS developments.

7 Conclusion and Summary

The HF-RTP tailoring steps were described for the Automotive use cases in the previous document D9.2. This set of tailoring steps were refined in the next document D9.4. Based on that, the development of the D1.5 resulted into the four main steps for the generic tailoring process to be applied in the different domains that are part of the HoliDes scope. In this document, a review of that tailoring steps has been updated.

Furthermore, this document provides a big picture of what added value can provide the current status of the AdCoS developments to the Automotive domain in the scope of the Holides project. The adaptation of each one of the AdCoS has been supported by the tailoring steps and we can extract some helpful conclusions for each one of the particular cases we've dealt with.

The AdCoS developed in the Automotive domain are reaching maturity level allowing for their evaluation and testing scheduled for the upcoming period. The integration of HF-RTP and relevant methods, techniques, and tools leads to particular feedback to the work packages providing the tools.

8 Way forward and upcoming activities

As is planned, the next step for the development of the AdCoS is the preparation for the testing and validation phases, once the development process is completed. This testing and validation processes will allow to detect errors and components not working properly, and from another point of view, a matching with the original requirements elicitated will allow confirm that the resulting systems and AdCoS fullfil the original requirements that they were designed for accomplish.

Glossary

ACC = Adaptive Cruise Control

ADAS = Advanced Driving Assistance Systems

AdCoS = Adaptive Cooperative Human-Machine Systems

CAN = Controller Area Network

DODAF = Department of Defence Architecture Framework

DAS = Driving Assistance Systems

EV = Ego Vehicle

FCW(S) = Forward Collision Warning (System)

HF = Human Factors

HF-RTP = Human Factors Reference Technology Platform

HMI = Human Machine Interaction

HMS = Human Machine Systems

HoliDes = Holistic Human Factors Design of Adaptive Cooperative Human-Machine Systems

MOVIDA = Monitoring of Visual Distraction and risks Assessment

MTTs = Methods and Techniques

PADAS = Partially Autonomous Driving Assistance Systems

RTP = Reference Technology Platform

UC = Use Cases

V-HCD (platform) = Virtual Human Centred Design (platform)

WP = Work Package